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GEOPHYSICAL VARIABLES AND BEHAVIOR: XCV. ANNUAL JANUARY RAINFALL MAY MODULATE THE INCIDENCE OF LUMINOUS PHENOMENA WITHIN THE SAN FRANCISCO BASIN[1]

J. S. DERR AND M. A. PERSINGER

United States Geological Survey *Laurentian University*

Summary.—The role of precipitation as a modulator of processes that influence the numbers of reports of anomalous luminous phenomena was investigated within the San Francisco Basin for the years 1950 through 1969. More than 50% of the variance in the numbers of these reports was accommodated by the amount of rainfall during the months of January. The relationship was strongest for events within 100 km of the city. Years in which January rainfall exceeded 8.5 in. and the numbers of earthquakes within the basin increased were associated with the largest numbers of general reports within 400 km from the city, particularly if the previous year had been drier and displayed less seismic activity. Application of the equation to years 1970 through 1995 predicted that above average (z score > 1.5) numbers of luminous displays should have occurred during the years 1973, 1993, and 1995. The results support the corollary of the tectonic strain theory that fluid injection or hydrological loads, natural or man-made, can affect the processes of tectonic strain which facilitate the creation of unusual luminous phenomena.

Luminous aerial phenomena, which are usually odd spherical or elliptical lights that display unusual kinetics, have been reported for centuries (Persinger, 1990). The Tectonic Strain Hypothesis for luminous phenomena predicts that most of these unusual energetic displays, frequently labelled as Unidentified Flying Objects, are derived from stresses within the earth's crust. As regional stresses increase, luminous phenomena are generated. If the stresses continue, earthquakes occur. The space-time transience of these natural phenomena are presumed to be determined by the constricted parameters that reflect interactions between geophysical factors. Derivative functions, such as the rate of change in strain, would determine the duration of these optimal conditions in real time.

The first corollary to the Tectonic Strain Hypothesis is that any factor that affects crustal stress within the region should increase the probability of the production of luminous phenomena and the occurrence of earthquakes. Changes in crustal loads which are associated with sudden (relative to the elastic properties of the bedrock) alterations in volumes of water within reservoirs or lakes have been correlated temporally with episodes of luminous

[1]Please send correspondence to Dr. M. A. Persinger, Center in Mineral and Mining Exploration Research (CIMMER) or Department of Psychology, Laurentian University, Sudbury, Ontario, P3E 2C6 Canada.

phenomena as well as significant earthquakes (Derr & Persinger, 1990a; Persinger & Derr, 1990). Because both classes of phenomena involve geophysical processes, the time frames may require months to years and involve perimeters of tens of thousands of kilometers. Episodes of luminous phenomena may have been associated with the draining of the Aral Sea, the filling of the Aswan Dam (Egypt), and the deflection of local rivers into small reservoirs (Derr & Persinger, 1989; Persinger & Derr, 1993).

Natural hydrological fluctuations, which are primarily the consequences of local or regional rainfall, influence loads upon river systems and may account for the seasonal variations in luminous phenomena and the numbers of earthquakes (Derr & Persinger, 1993). For example, there was a pronounced seasonality in California earthquakes preceding the great 1906 San Francisco earthquake (McClellan, 1984) although no corresponding data base for luminosities is available. Injections of fluids into underground crustal vaults by human industry can also generate earthquakes. If these correlative reports of luminous events reflect the aseismic diffusion of strain fields, then the consequences of these hydrological pulses may extend more than 400 km from the source (Persinger & Derr, 1993).

Intuitively, natural geographical basins or valleys would allow greater containment of fluid such that its effect upon tectonic processes and the generation of luminous phenomena may be more conspicuous. We decided to test this possibility by examining the yearly incidence of luminous phenomena within the San Francisco Bay area (California). It has a basin structure. Years of marked precipitation within the basin have been associated historically with delayed seismicity. If slowly escalating tectonic strain occurs between the time the process is initiated by precipitation and the occurrence of overt seismicity, then the increment of strain associated with the generation of luminous phenomena should be prolonged. The probability of observation should be increased.

The logical prediction is that the numbers of reports of luminous phenomena, which are assumed to be a highly correlated sample of the incidence of actual natural events, should vary systematically, from year to year, with the amount of local rainfall. The effect size for the contribution of precipitation to the variability in numbers of reports of luminous phenomena should be enhanced within this region because of its chronic tectonic stress as indicated by the prevalence and incidence of earthquakes.

Method

To test this hypothesis, the numbers of reports of luminous events per year for the years 1950 through 1969 within 100 km of San Francisco were obtained from our copy of the data base from the Center for UFO Studies (CUFOS). This interval was selected because it represented the central por-

tion of the data base and appeared to be least affected by the beginning and the termination of the motivation to document cases. Redundant entries, defined as the report of more than one event for the same day and the same locality, had been removed. The classification of entries involves the Saunders-Hynek strangeness scale (0 to 9); it inherently reflects a range from minimal to maximum deviations in perception of known physical phenomena. Very probably misperceived phenomena were classified after-the-fact by CUFOS personnel as Type 0 (5% of total cases) while Types 1 and 2 (19% of all entries) were likely to have been conventional (satellites) phenomena. These served as our control cases.

Types 3 through 7 (24% of all entries) constituted the classical descriptions of luminous phenomena, e.g., odd, multicolored balls of light with unusual movements and some intrinsic perceptual stimuli such as lines or compartments of color (about half of these cases were Type 5). They served as our cases of Specific Luminous Phenomena. [Although Type 7 was not included in our previous studies, this type loaded on the same factor dominated by Types 3 through 6 and consequently were included in these analyses as Specific Luminous Phenomena]. Because 51% of the cases in the data base were not classified by CUFOS personnel but the temporal variation of these events has been shown to be most correlated with the numbers of Specific Luminous Phenomena, these cases were combined with the latter to form a category of General Luminous Phenomena (Derr & Persinger, 1990b). This variable was also included because of the relatively small numbers of cases classified as Type 3 through 7 and the likelihood that specific classifications, i.e., evaluation of each case, had not been consistent during the 19-yr. period. To test the hypothesis that the General Luminous Phenomena within 100 km of San Francisco should be most strongly associated with the rainfall, the total numbers of General Luminous Phenomena between 101 and 200 km and 201 and 300 km were also extracted for analysis with the data for precipitation and seismicity.

The annual rainfall (in inches) for San Francisco as well as the monthly values were obtained for the years 1950 through 1996. Visual inspection quickly indicated that the January rainfall varied systematically with the annual numbers of reports of luminous phenomena during the target interval (1950 through 1969). Consequently, two hydrological variables were selected, total annual rainfall and rainfall during the month of January for each year.

The total numbers of earthquakes per year within 100 km were obtained from the U.S. Geological Survey. Total energy yield per year was calculated according to a traditional formula (Derr & Persinger, 1990b). Finally, since geomagnetic activity has been empirically associated with the incidence of both local and global episodes of luminous phenomena within the

last century and UFO reports in the latter half of this century, the annual average antipodal (aa) index of Mayaud (1973) was included. The values of aa in nanoTesla for more recent years was obtained from the Geomagnetic Indices Bulletin (National Geophysical Data Center, Solar-Terrestrial Physics Center, 325 Broadway, Boulder, Colorado, 80303). The standard deviations of the monthly aa values per year were calculated because our model predicts that the amount of variability, in a manner similar to rates of change, should contribute to large-scale telluric phenomena whose brief, spatial focusing would facilitate the occurrence of single luminous events or clusters of these events within a locality of about 100 km-squared to 10,000 km-squared. The process would be analogous to transient steady-state geomagnetic anomalies created in ore deposits by global geomagnetic storms.

There were two stages of the analysis. The first was to test the hypotheses that (1) the variation in the numbers of reports of anomalous luminous phenomena within the vicinity of San Francisco were strongly correlated with annual rainfall while "control cases" were not and (2) the association is most affected by the January rainfall rather than the total rainfall (partial correlational analysis). Consequently, by obtaining information for January rainfall the numbers of anomalous luminous phenomena within 100 km of San Francisco during the subsequent year might be predictable.

The second stage of the analysis was to discern by step-wise multiple regression which combination of variables best predicted reports of Specific Luminous Phenomena and General Luminous Phenomena. The additional independent variables were average antipodal activity, the standard deviation of the monthly averages of the aa indices, the numbers of quakes within 100 km of San Francisco per year, and the total energy released by these quakes per year. Values for the contemporary and previous year (lag = 1) were employed. To discern the internal consistency of the equation the values predicted from the equation for the first 10 years of the interval (1950–1960) were correlated with the observed values for the numbers of anomalous luminous reports for the next nine years. Finally, an equation for the entire 19 years was constructed that was applied to the subsequent years 1970 through 1995. So that the parameters could be applied to other data bases, the z scores for the variations of the numbers of annual reports of general anomalous luminous events were employed. This means that the equation could be applied to any data base once the annual numbers of luminous phenomena were converted to z scores referenced against the mean for any successive period of about 20 years. All analyses involved SPSS software on a Vax 4000 computer.

Results

The means and standard deviations for the annual January rainfall and

total rainfall in San Francisco, aa values and the standard deviations for their monthly averages, numbers of recorded earthquakes, coefficient for the release of seismic energy (times 10 to the power 17 ergs), and the various types of anomalous reports are shown in Table 1. The Spearman *rho* correlations (Table 2 upper half) indicated that only the numbers of reports of Type 3 through 7 (specific) unusual luminous events increased significantly during the years of increased rainfall during the months of January.

TABLE 1
MEANS AND STANDARD DEVIATIONS FOR KEY VARIABLES OF ANALYSES FOR YEARS 1950–1969

Variable	*M*	*SD*
Rainfall, in.		
January	4.6	2.6
Annual	20.0	5.1
Geomagnetic Activity		
M aa	23.1	5.3
SD of aa	18.7	6.2
Earthquake Activity Per Year		
Numbers of earthquakes	49.4	50.5
Energy Release ($\times 10^{17}$ ergs)	24.3	72.1
Luminous Phenomena Per Year		
< 100 km from San Francisco		
Type 0 Reports	1.4	2.1
Type 1, 2 Reports	3.6	3.4
Type 3–7 Reports (spherical)	3.2	2.9
General Luminous Reports	13.5	13.4
101 to 200 km from San Francisco	7.6	6.3
201 to 300 km from San Francisco	2.6	1.1
>300 km from San Francisco	63.3	50.5

The zero-order (Pearson) correlations between the amount of rainfall during the months of January and the total rainfall per year and the occurrence of various types of reports are also shown in Table 2 (lower half). Years in which greater hydrological loads occurred (due to rainfall) during January were associated with more frequent reports of the Specific Luminous Phenomena and General Luminous Phenomena but not increases in misperceptions (Type 0) or mundane lights (Types 1, 2). It may be of interest that there were no listings of the Specific Luminous Phenomena beyond the 100 km radius for this interval. For the general anomalous luminosities, the association with January rainfall was noted for the reports occurring between 101 and 200 km from San Francisco but not for greater distances.

Following partial correlation after the shared variance with the total rainfall had been removed, the association between the Specific Luminous Phenomena and January rainfall was still present ($p < .01$). However, the as-

TABLE 2

SPEARMAN *Rho* CORRELATIONS (UPPER HALF) AND ZERO-ORDER AND PARTIAL CORRELATIONS INVOLVING RAINFALL (VARIABLE HELD CONSTANT IN PARENTHESES) FOR KEY VARIABLES (LOWER HALF)

Report Type	Rainfall		
	January	Total Annual	No. of Quakes
Type 0	−.17	−.19	−.07
Type 1, 2	.27	.35	.05
Type 3–7 (spherical)	.42*	−.04	−.42*
Type 3–7/unclassified			
< 100 km	.50*	.10	−.45*
101–200 km	.33	.15	−.35
201–300 km	−.01	−.12	−.02

	Rainfall			
	January	Total	Jan. (Total)	Total (Jan.)
Type 0	−.17	−.14	−.11	−.07
Type 1, 2	.35	.50*	.12	.40*
Type 3–7 (spherical)	.77†	.51*	.46*	−.07
Type 3–7/unclassified				
< 100 km	.66†	.52*	.68†	.22
101–200 km	.64†	.39	.55*	.11
201–300 km	−.24	−.11	−.24	.02

*$p < .05$. †$p < .01$.

sociation between these luminous events and total annual rainfall was no longer significant statistically if the contributions from the January rainfall were first removed. Only the association between total rainfall and the reports of more mundane lights (Type 1, 2) remained significant statistically.

The results of the multiple regression analysis for the first 10 yr. of the data base showed that only the amount of January rainfall (MR = 0.76) entered the equation ($F_{1,8} = 11.10$, $p = .01$). The predicted values from the resultant equation: 1.99 multiplied by the January rainfalls in inches and the constant 5.62 (Durbin-Watson value for the equation was 2.02) was correlated (r) .74 ($p < .05$) with the numbers of reports of Specific Luminous Phenomena for the *subsequent* 9 yr. (1960 through 1969). This statistically significant correlation verified the reliability of the association between annual January rainfall and the report of luminous phenomena for years beyond those generated by the equation.

When all 19 years were included in the equation, January rainfall entered primarily. The only additional variable to enter the equation was the annual aa values. The multiple R was .83 ($F_{2,16} = 18.29$, $p < .001$; adjusted $r^2 = 59\%$). The equation was .30 multiplied by the January rainfall minus −.10 multiplied by the aa value plus .93. The partial regression slopes were determined for the z score of the numbers of General Luminous Phenomena

per year which had been derived from the mean and standard deviation for numbers of reports during the 19-yr. period. This was completed so that the equation could be potentially applied to any data set of luminous reports within the San Francisco area. The beta coefficients were .74 for January rainfall and −.52 for the aa values. Values for the lags (the year before) did not enter the equation. The scattergram for the predicted and expected values according to the equation generated from the two independent variables are shown in Fig. 1. Visual inspection of partial plots demonstrated linearity and absence of outliers.

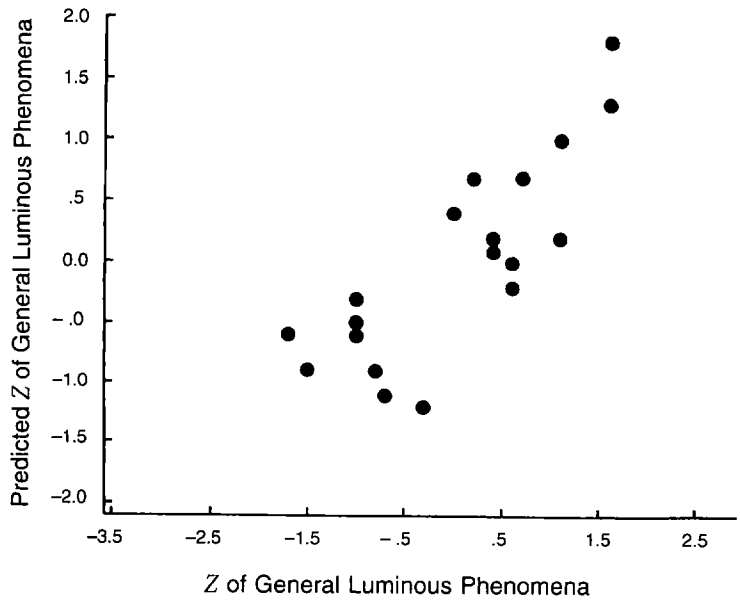

FIG. 1. Scattergram of the correlation between the predicted value from the equation for General Luminous Phenomena and the observed value for standardized scores of numbers of General Luminous Phenomena within 100 km of San Francisco

Anomalous luminous events that are coupled to tectonic strain which can increase to levels sufficient to produce earthquakes may occur hundreds of km from the imminent epicenters. If the optimal increment of space is employed that characterizes the relationship between phenomena, the strength of the association is maximized (Persinger & Lafreniere, 1977). The relationship between time and space to discern a functional entity or phenomena within any level of scientific discourse is relatively fixed. For example, picosecond increments are required to perceive the functional distinctions of picometer space (atoms) while millisecond increments are required

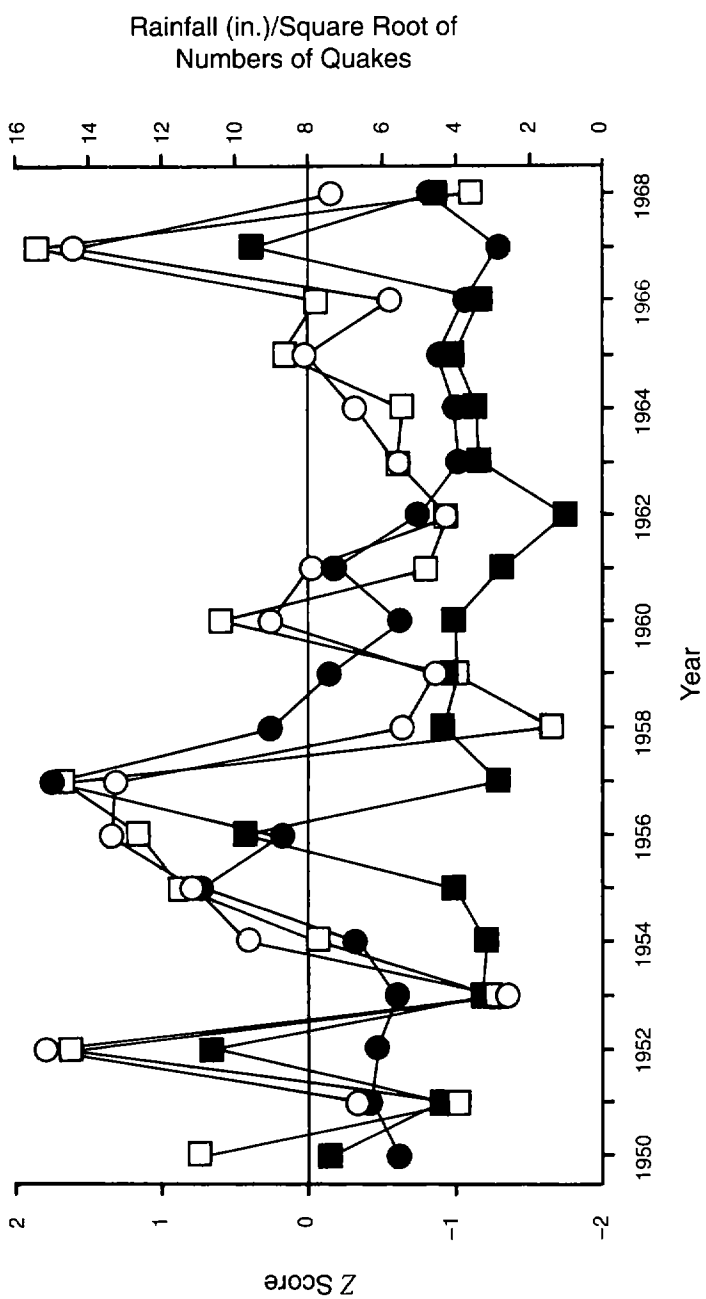

FIG. 2. Plot of z scores for total numbers of General Luminous Phenomena (□) and predicted numbers of reports (○) as well as the square root of the numbers of earthquakes (●) and the January rainfall (■) for the observation period

to perceive the functional distinctions of millimeter space (the action potential). Temporal increments less or greater than the optimal occlude or mask the phenomenon in question by overinclusion or excessive fragmentation.

To test this possibility we performed a *post hoc* analysis with the standardized (z) scores for the total numbers of general luminous phenomena within 400 km of San Francisco during the 19-yr. period and the same variables for rainfall, seismic activity, and aa activity that had been employed in our *a priori* design. Although the distribution of the reports would be distorted along a north-south axis (the shape of the state), the fault lines are also along this plane. We realized that the population density would decrease and hence the homogeneity of the "instruments" (human observers) would be less than within the basin. However, this should only affect the absolute numbers of reports rather than the strength of the correlation with geophysical and meteorological variables.

The results of the multiple regression analyses supported the prediction. The multiple R was .95 ($F_{4,14} = 10.12$, $p < .001$; adjusted $r^2 = 87\%$). The equation was (0.32 × January rainfall −0.8 × total annual rainfall, +0.19 × square root of numbers of earthquakes − .11 × square root of numbers of earthquakes the previous year −.25). The Durbin-Watson measure for the equation was 2.04. To discern internal reliability, a specific inductive equation (which involved the first three of the above variables) for the first 10 yr. of the interval was obtained. The correlation between the predicted values from this equation for the next 9 yr. and the observed values was .84 ($p < .05$).

Discussion

These results support the hypothesis that the amount of rainfall within a geographical region whose topography facilitates the collection of precipitation can modulate the incidence of luminous phenomena that are reported locally. That the association between precipitation and luminous phenomena was due to some general confounding variable, such as reporting, is not likely in light of the absence of statistically significant correlations between January rainfall and either highly suspected misidentifications (Type 0) or mundane linear movements of lights (Types 1 and 2). A central association between the specific luminous phenomena and January rainfall is further indicated by results that reports of luminous events beyond 200 km from San Francisco were not strongly associated with local precipitation.

The role of regional ground water as a variable that modulates stress has been suggested (Derr & Persinger, 1993). Historically, the largest epidemics of the reports of unusual luminous displays (or their culture-specific variations) within regions have been closely contiguous with above average precipitation that usually followed droughts. For example, the massive display of luminous "airships" during the last decade of the nineteenth century

followed massive flooding in the Mississippi River System (and was punctuated by one of the largest earthquakes within the region).

The results of the present study suggest that months of January in which the largest rainfall occurred were associated with an enhanced incidence of general luminous phenomena (particularly if the previous year had been relatively dry) during the remainder of the same year. The most extreme years for reports of general luminous events occurred when the January rainfall exceeded 8.5 in. The equation showed that years that were associated with particularly copious numbers of reports within 100 km from San Francisco were 1952, 1956, and 1967 and should have been (by prediction) 1973, 1993, and 1995.

The mild to moderate negative association between the numbers of earthquakes within 100 km of San Francisco and specific luminous phenomena and earthquakes originates from a common source of variance: tectonic strain. If it accumulates slowly through the optimal increment, then luminous phenomena are generated for longer periods of time. If the strain accumulates more quickly, then fewer luminous phenomena would be observed before the earthquake. Because analyses that involved monthly or 6-mo. increments of analysis (rather than yearly increments in this study) have generally indicated that luminous phenomena precede numbers of earthquakes, we have suggested that luminous events are generated (and their reports are registered) when there is a specific range or rate of strain which usually occurs during the 6-mo. increment before the strain values that precipitate earthquakes.

Within regions where earthquakes are relatively infrequent the tectonic strain would not be maintained within levels that would allow fluctuations within the ranges sufficient to produce both luminous phenomena and earthquakes. However, some areas, such as the San Francisco region and portions of southern Italy and Japan would be characterized by persistent tectonic stresses that could oscillate within the bands of strain sufficient to evoke spherical luminous phenomena and seismic events.

Within areas larger than 10,000 km-squared, the more frequently observed relation between indices of increasing strain and increased numbers of reports and luminous phenomena becomes more conspicuous. Within a radius of 400 km around San Francisco increased reports of General Luminous Phenomena could be retrospectively explained by the combination of less annual rainfall and fewer numbers of quakes the year before but more frequent earthquakes and rainfall during January of the same year as the luminous events. Interpreted alternatively, the positive temporal association between the numbers of luminous events and the numbers of earthquakes within geological regions can be occluded in areas where strain is persistent and powerful trigger variables, such as rainfall, modulate the tectonic strain.

REFERENCES

DERR, J. S., & PERSINGER, M. A. Geophysical variables and behavior: LIV. Zeitoun (Egypt) apparitions of the Virgin Mary as tectonic strain-induced luminosities. *Perceptual and Motor Skills*, 1989, 68, 123-128.

DERR, J. S., & PERSINGER, M. A. Geophysical variables and behavior: LXIII. Quasi-experimental evidence of the tectonic strain theory of luminous phenomena: the Derby, Colorado earthquakes. *Perceptual and Motor Skills*, 1990a, 71, 707-710.

DERR, J. S., & PERSINGER, M. A. Luminous phenomena and seismic energy in the central U.S.A. *Journal of Scientific Exploration*, 1990b, 4, 55-69.

DERR, J. S., & PERSINGER, M. A. Geophysical variables and behavior: LXXVI. Seasonal hydrological load and regional luminous phenomena (UFO reports) within river systems: the Mississippi Valley Test. *Perceptual and Motor Skills*, 1993, 77, 1163-1170.

MAYAUD, P. N. A hundred year series of geomagnetic data: aa indices and storm sudden commencements. *IAGA Bulletin*, 1973, 33. [Entire volume]

MCCLELLAN, P. H. Earthquake seasonality before the 1906 San Francisco earthquake. *Nature*, 1984, 307, 153-156.

PERSINGER, M. A. The tectonic strain theory as an explanation for UFO phenomena: a nontechnical review of the research, 1970-1990. *Journal of UFO Studies*, 1990, 2, 105-137.

PERSINGER, M. A., & DERR, J. S. Geophysical variables and behavior: LXI UFO reports in Carman, Manitoba and the 1975 Minnesota quake: evidence for triggering by increased volume of the Red River. *Perceptual and Motor Skills*, 1990, 71, 531-536.

PERSINGER, M. A., & DERR, J. S. Geophysical variables and behavior: LXXIV. Man-made fluid injections into the crust and reports of luminous phenomena (UFO reports): is the strain field an aseismically propagating hydrological pulse? *Perceptual and Motor Skills*, 1993, 77, 1059-1065.

PERSINGER, M. A., & LAFRENIERE, G. F. *Space-time transients and unusual events*. Chicago, IL: Nelson-Hall, 1977.

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